

# **Infusing Statistical Engineering**

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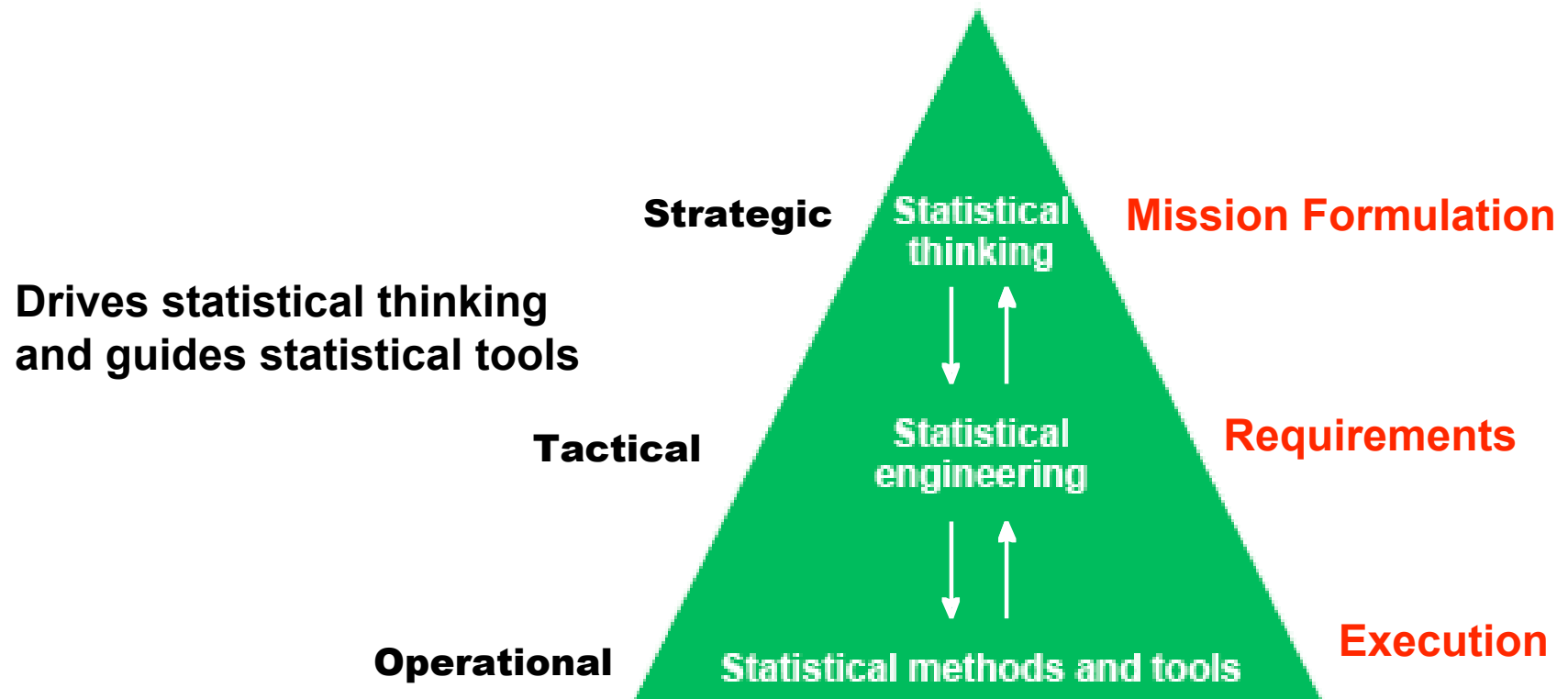
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# Statistical Engineering at NASA



- Engineering **discipline** to efficiently gain **knowledge** through strategic **resource** investment
- Applies **systems thinking** to high-level, well-defined objectives
- Synergistic combination of existing tools to solve complex problems



# Defining Rocket Motor Requirements



- Leveraging heritage design for a new application and requirements

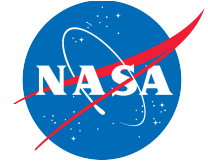
## Original Question

- How to measure roll torque during a firing to size the reaction control system?
- Impacts requirements, cost (lifecycle), schedule, volume, mass (payload)

## Statistical Engineering Applied

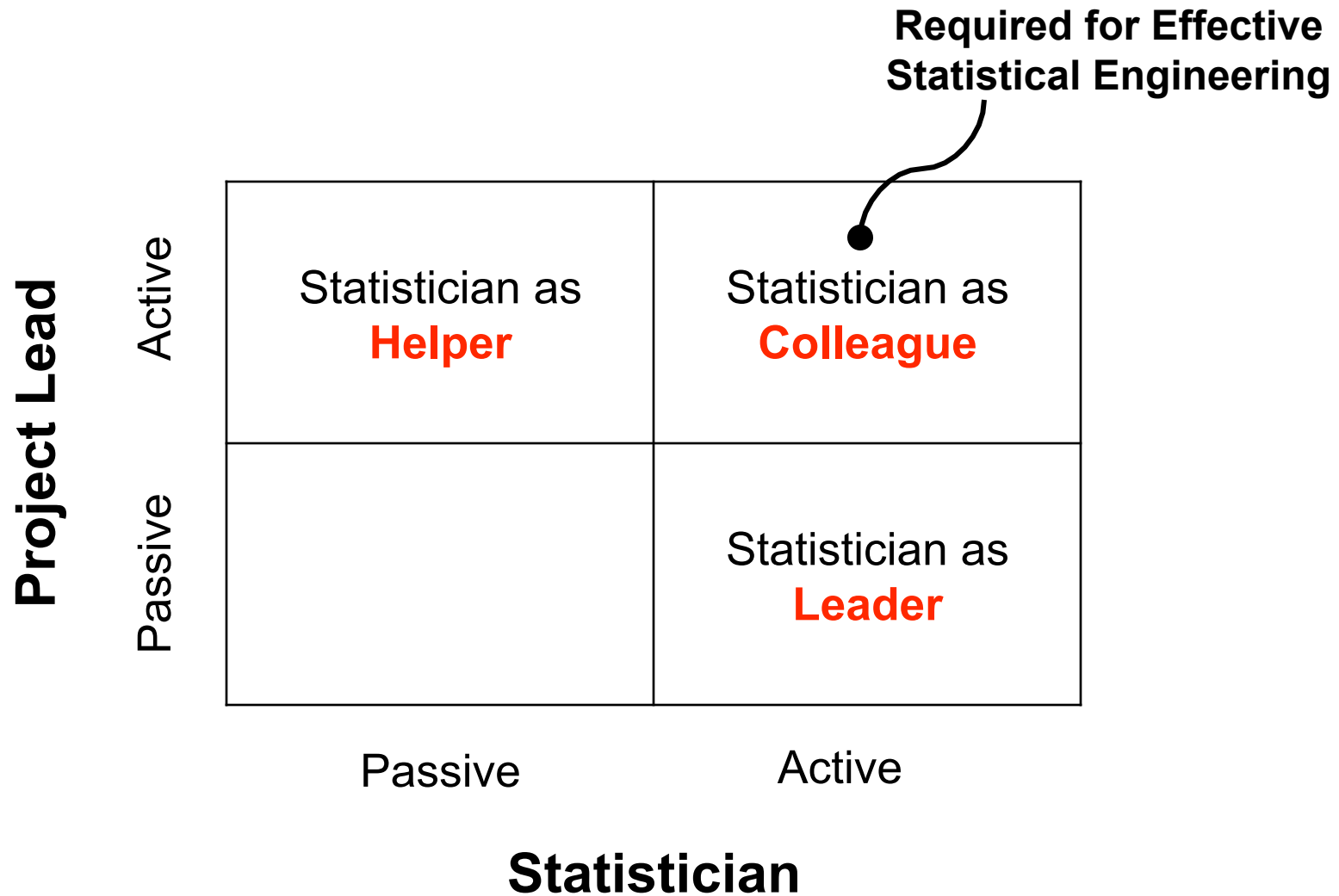
- System level – studied apparatus, available theory and data
- Integrated design of experiments with force measurement expertise
- Measured roll torque, quantified uncertainty, reduced design risk
- Internally generated ballistics could not be rigorously isolated
  - Modifications to the firing duty cycle fully achieved objectives
- Embedded in processes, software, and training

# ***Motivation for Statistical Engineering***



- Consistent **methodological framework** for research and development
  - teachable, repeatable, scalable - not idiosyncratic
- Benefits of successful implementation
  - **Improved Decision-making** - risk-informed and defensible
  - **Technical excellence** – unequivocally define objectives, integrity of results/knowledge obtained
  - **Organizational excellence** - strategically applying resources
- Opportunity for statisticians to make greater contributions in achieving strategic organizational objectives

# Changing the Role of the Statistician



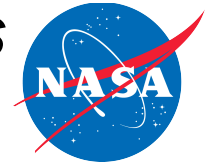
# ***Starts with Fundamental Questions***



- Heilmeier used as a preflight checklist for successfully launching a research project **to curb and clarify both the enthusiasm of the researchers and to evaluate the resource demands of the project managers**
- **What are the precise objectives?**
  - What are we seeking to learn?
  - Are the objectives quantifiable, detectable, measurable?
  - What is the impact if you are successful?
- **How well do we need to know the answers?**
  - How much risk are we willing to accept in being wrong?
  - What are the consequences if we are wrong?
- **Do the methods rigorously link to the stated objectives and risk?**
  - Are the resources justifiable and defensible?

***Questions apply recursively in the vertical direction down to systems and subsystems and horizontally throughout project life-cycle***

# Using NASA Satellite Data and Models for Socioeconomic Benefits



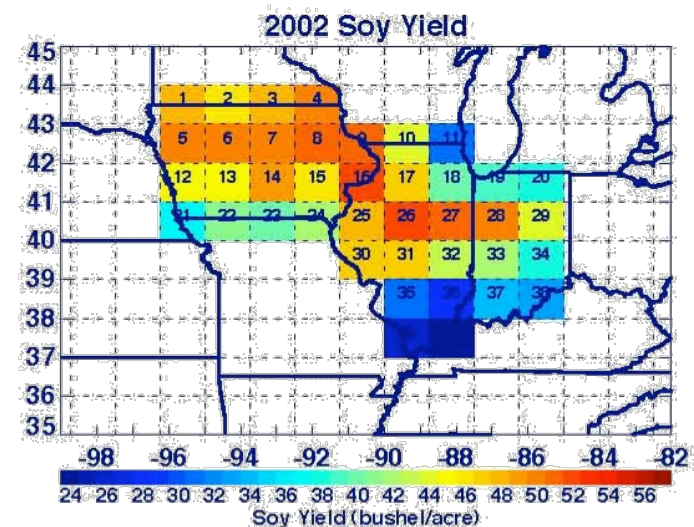
- Research into using ozone satellite measurements (Tropospheric Ozone Residual) to improve soybean crop yield

## Original Question

- Can we develop a correlation between satellite measurements and ground-based measurements of ozone?

## Statistical Engineering Applied

- Synthesized multidisciplinary team member ideas on the objectives to clearly define the research questions and approach
- Satellite and ground provide different types of useful information
- Modeled yield as a function of temperature, soil moisture, and ozone (satellite and ground)
- Impact: Provided new framework, impetus for additional research



# ***Vital Implementation Elements***



- **Leadership**
  - Requires leadership to convert a “good idea” into “the new way we do business”
  - Articulate motivation, communicate expectations, be accountable
- **Core Competency**
  - Discipline experts matrixed across programs/projects
  - Multidisciplinary skills are required
  - Teaming and communication skills are critical
- **Equipping People with Knowledge and Tools**
  - Broaden awareness of this discipline
  - Consult with researchers and lead engineers, equip practitioners
- To be seen as **value-added** and **measure effectiveness**

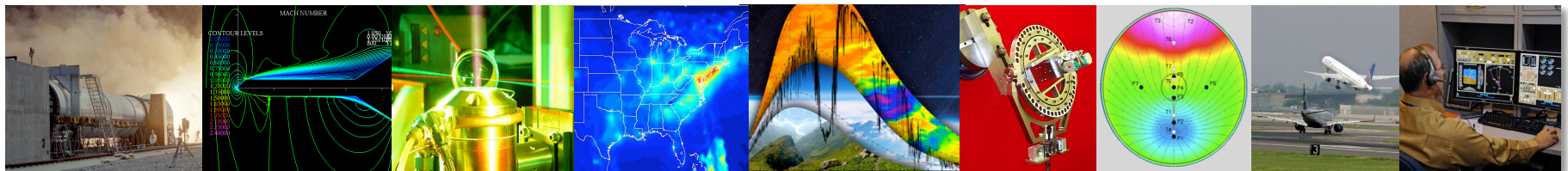
# *Our Progress at NASA Langley*



- Building a statistical engineering capability takes a deliberate strategy
- Obtained leadership support through **demonstrated benefits**
- Growing a core team with **multi-disciplinary competence**
- Broadened knowledge of the discipline by **recognized project impact**

## Areas we need to improve

- Inextricably link statistical engineering to organizational objectives
- Assist leadership to further engage and commit with specific actions



# ***Our Vision for Statistical Engineering***



- **Tactical Discipline that**
  - **Drives critical, statistical thinking** at the strategic level
  - **Guides statistical methods and research** at the operational level
- Improves our effectiveness in accomplishing our mission
  - Defines the right questions
  - Guides strategic resource investment
  - Accelerates research and development
- **Not a replacement for good science and engineering**
- To promote best practices within our Agency and profession